5.1

The Knower in the Known
A Theory of Information Synthesis

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Abstract

The paper presents an ecologically oriented theory of information synthesis. A model for the analysis of intentionality and orientation as expressed in natural language is put forward. The thesis is that knowledge is the result of an active inquiring agent (knower). His cognition rests on the extraction and abstraction of invariants. It is a mark of mentality that the knower always conceives the meaning of object-event relationships. Some of the assumptions for this approach are to be found in James J. Gibson's ecological theory of perception. For example, to perceive and conceive the environment are only different in degree but not in kind. As a consequence, the two key concepts perspective and viewpoint play a central role. The model developed rests on the ability to determine the agent function (perspective), which governs language production. Perspective control lies in the definition of the transposition of the agent. Thus the agent function determines what viewpoints are chosen and how they change throughout a text. A second assumption based on Gibson's work is that the meaning of objects is directly perceived and observed before the substance, surface, colour, or form, which implies that a pictorial and symbolic expression links perspective and viewpoints. On the basis of a series of pictures of the original visual cliff experiments it is discussed in what way verbal descriptions and textual transformations mediate the integration of experience as invariant structures.

When self-reference is concealed or non-detectable in verbal behaviour, it deprives us of the possibility of knowing what is symbolically expressed. If a verbal expression cannot be recognized as an intentional act, it cannot serve its purpose of providing meaningful information either. Our thesis thus is that human language must be recognized as a self-referential system. The states of such a system are determined by the mutual dependencies of its constitutive components. Self-referentiality implies that no master interpretation can be forced upon a text. The basic cues by which the human brain processes the origin and nature of the object-event relationship expressed are topological in kind.

Ecological events have a certain character, which can be processed only to the extent that they are mediated by the parts of language (e.g., modality, quality or quantity). The perceptions that can be discriminated according to variations in object orientation reveal what has been called " exterospecific information " (Gibson, 1979) to the organism. After this kind of information has been available,an organism (individual) can extract the ecological invariants and intentionally express (symbolize) them in a natural language. Regan, Beverly and Cynader (1979) have demonstrated highly specific pathways for the processing of motion specific cues, and this uniqueness is absolutely necessary, because there is no uniqueness of signals. In addition, Ball and Tronick (1971), in a psychophysical experiment, could show that infants of only a few weeks of age can meaningfully respond to symmetrically expanding shadows, optically specifying an approaching object. These topological cues regarding modality and quality are processed in a strictly self-referential way.

Through Kennedy's (1980) studies it further became evident that childrens' perspective and viewpoints need not necessarily be interpreted as belonging to experience of vision, but should be regarded as factors with cognitive properties. Therefore, in an analysis of language expressions it will be of importance to treat perspective and viewpoint differentially, since any verbal description of object-event relationships incorporates both optic-

al and perspective invariants. But informational invariants emerge only if self-reference is conceived of as an integrative component in a schematizing process. Isolating the components' effect implies that "propriospecific information" (Gibson, 1979) becomes available.

By anchoring the concept of knowing in these two poles, knowability needs not be founded on simplified relations (i.e. associations) with the help of which are computed relations of greater complexity. Informative components emerge only if uniqueness can be detected or if known information can be transformed (operation of a schematization). The implications of the schema mechanism assumed for a demonstrative definition of knowability have been illustrated through experimental research (Bierschenk & Bierschenk, 1987).

The Architectural Configuration of Coordinative Structures

Observing behaviour in individuals acting purposely in a meaningful environment is hardly possible without the organism's expression of an "intended" and "oriented" schematization. Observation presupposes not only that a structure can be specified but also that intentionality and orientation can be observed. In order to get hold of the intention it becomes necessary to apply the schema concept to the observation. This may be illustrated with the expression

$$\emptyset \quad \text{action} \quad \emptyset \qquad (1)$$

This schema incorporates the intention of an agent, that governs its choices of viewpoints expressing the orientation. The transitive property of the schema (1) is marked by means of two place holders, i.e. one dummy variable is placed before and one after the action. This assignment symbolizes the absence of the agent, i.e. someone who knows something about reality. To know something about reality requires that something can be said about its knowability. Thus the information embedded in the structure presen-

ted (1) becomes accessible only in relation to activated components. The kind of variables they manifest depends on what is being realized through the action component. It follows that knowledge is conceived as something that exists only through a cooperative interaction between the individual and its environment.

In his attempts to study knowability (i.e. knowledge as a process), Piaget (1963) takes his point of departure in the infant's thumb sucking behaviour, which he sees as the behavioural manifestation of the formal structure (1). The infant's sucking is conceived as part of a " sensory-action schema " and as one of the earliest schemata. According to Piaget, the schema is the basic control mechanism in the development of the organism's behavioural and cognitive abilities. Through schematizing processes the infant extends its repertoire of actions " without any representation of thought " (Piaget, 1978, p 7). Cognitive schemata are derived from action schemata by a process of internalization. Thereby it is assumed that the schema as a basis for formalization creates a cognitive organization, primarily through cyclic or recurrent activities. Consequently, the function of the schema should be observable in the development of knowledge.

The Schema Hypothesis

The hypothesis of a schema as primary means for a study of the knower and the known (reality) was first utilized by Kant, who during the 18th century tried to formulate the principles for a foundation of knowledge. Kant's main argument is that knowing should be seen as a cooperative act between a knower's way of organizing information on the basis of categories and the known giving context to the process of perception. The notion of schema refers to some cognitive mechanism, which Kant postulated necessary as a mediator between such cognitive functions as categories on the one hand and sensory input from the environment on the other. Consequently, Kant labelled the product of a schematizing process " imagination " (" Einbildungskraft ").

Notice that the notion " cognitive " is here used in a technical sense to indicate that the organism knows the result of its behaviour in a given environment. Moreover, it is used to mark an abstraction and not as a notion for representation, even though the term " representation " is very often used synonymously with cognition. To assume that the brain has the capacity to build a cognitive system, it is necessary to postulate an a priori principle, the schema. The brain has to create a presentation of reality. But this cannot be a re-presentation, because it has no direct access to the environment.

It is clear from the writings of Head (1920, p 831) that he found the notion of schema suitable for designating a dynamic structure conserving the observed relations between continuously changing posture and the integration of fresh arriving sensory input into the cortex. Only a decade after Head stated that it is the existence of schemata that gives humans " the power of projecting the recognition of posture, movement and locality beyond the limits of the body " (Head, 1920, p 606), his concept was extended by Bartlett (1932), who integrated the idea of self-reference. This aspect is already present in the writings of Head, though. Self-reference implies that there is no " master interpreter " in the brain. Thus the self is itself a construct, and not the constructor of the cognitive system. In this perspective, the schema is the mediator between meaning and being. Virtually in agreement with Kant, Head, and Bartlett it can be emphasized that the constructive capability of the schema produces the environment in which the human being exists, but it cannot change the perception of it. Hebb (1980) writes:

> What one is aware of in perception is not a percept but the object that is perceived; what is given in imagination is an illusory external object, not an internal mental representation called an image. (p 18)

From the perceptual point of view, the notion of schema was reconsidered by Gibson (1966; 1979), who claimed that the perceptual experience is direct and flows immediately from what he conceives as the relationship of superordinate components, which is

his definition of the schema. According to Gibson, the brain seems to differentiate perception and behaviour on the basis of invariants, which make possible that the behaving organism can observe itself through immediate information pick-up. Gibson agrees that stimulation is necessary for the activation of the perceptual system. But the stimulation of the receptors in retina, he points out, cannot be seen. Instead, the function of the retina should be thought of as a means of registering " invariant structure " (Gibson, 1979, p 56). This hypothesis is intended to close the gap between " perception and knowledge " (p 258). The organism knows by means of the schema if it has been influenced by an event in the environment or if it itself influences the environment by causing an event.

From Gibson's point of view, it is important to separate the invariant structure of objects and events from perspective structure if one wants to study the organism's reactions to its environment. For him, perception depends on the detection of invariants over time. The schema is therefore the cognitive device for successful coping with reality. In this sense, schemata can be conceived of as a priori determinations of time, or as Gibson aptly expresses it, as " formless invariants over time ". It is to notice that Gibson (1979, p 3) seems to mean that he does not at all build on the Kantian approach. This appears to be a misconception of the Kantian approach, because Kant argues in the same way as Gibson does when he makes sure that, to him, experience of reality is immediate and not mediate.

The unifying aspect in the discussion of the schema hypothesis from Kant to Gibson seems to be these authors' agreement on the schema as the conceptual tool for integrating temporarily separate events, and their conception that the roots of the schema are to be thought in the behavioural endowment of the organism. In fact, it was Piaget who pointed out that the schema is conserved in the behaviour of the organism itself. He states (Piaget, 1978, p 254) it clearly when he writes that " the roots of such schematism are innate whichever way you look at them ". Therefore, the idea of a schema existing not only in cognition but also in

behaviour before any thought or idea of self has been established is original to Piaget. His basic argument is that the preservation of a schema has no need for a memory, because the schema of an action is " the quality in the action " (Piaget, 1978, p 187).

In addition, Kant, Piaget, and Gibson assume that perception of reality is possible only by means of a space-time coordinate, although Gibson has in mind a terrestrial environment, that is processes and changes of sequences, and not, as is the case of Kant and Piaget, Newton's concept of space and time. Kant and Gibson both claim that the objective reordering of information picked up (subjective succession of cognition) actually is a synthetic reorganization, which is an a priori act of human mind. It seems, however, unwarranted to accuse Kant of having developed " a rigid and resolutely static framework ", as Piaget does (1978, p 314). (See further B. Bierschenk, 1981.)

The Schematism of Language

However rigid and static, or flexible and dynamic a notion of schema the authors had in mind, it must be granted that human beings act on cognitive functions and that their actions, especially their verbal behaviour, express a high degree of schematization. Thus there is very little reason to doubt the preciseness and completeness of natural language when used in a natural context. Moreover, there is every reason to believe in people's ability to use their language in specifying unambiguously their perceptions and conceptualizations. As will become obvious at the symbolic and conceptual levels, the environment is not only reacted to and acted upon, but is understood through the processing of information picked up from symbols.

The schema (1) marks the structural aspect of a graphical or symbolic expression. It incorporates the assumption that the motivation or interest of the agent governs the choice of viewpoints, which means that the perspective is latent in the verbal flow. When the purpose is to analyse various agents' intentions, it becomes important to operationalize the schema (1). This may be re-

alized through the action " to study "

? study ? (2)

In that the components are being operationalized by question marks, variable manifestations within a specified context can be studied. An example of a variable manifestation may be the expression:

The researcher observed infants (3)

The variables in the expression (3) may be regarded as an observation belonging to a scientific context. The researcher is the agent who perform a series of actions, and the infants the ones who function as the objective of observation and study. The relation between the discrete variables (researcher, infants) is then given in the relationship holding between Agent and its Objective (1). Thus the possibility of presenting an observation prerequires the distinguishing of an agent and the objective of its action. At the same time, such a paradigmatization into the

Agent - action - Objective (4)

schema imposes a constitutive function on the context.

Distinctive of the ecological approach to verbal behaviour is its foundation on the following assumptions:

1. Verbalized behaviour or text is an expression of an agent's (A) interaction (a) with some environment (O).
2. The experience of the agent builds on actions which incorporate both intention and orientation, implying both to be integrated in the verbal flow.

If, for example, it may be assumed that infants (3) represent not objects of study but the phenomenon of development, then their behaviour would be studied. The phenomenon, the scientific focus, is being elucidated through the infants acting towards certain specific objectives. Therefore, the researcher's observations ma-

nifest themselves in a series of AaO relations at the moment of observation. When it comes to present those observations, this is continuously done in the form of a process, that is the observations are given a syntactically coherent form (text). (Fig. 1).

Figure 1 about here

In general, any awareness that can be formalized into text would be an expression of a purposive process. The model (1) has led to the construction of an algorithm, which differentiates perspective from viewpoints and makes possible an ordered, coherent, and consistent presentation of reality (Bierschenk & Bierschenk, (1986, a; b; c). Thus we postulate that the quality in verbal expressions is defined by their underlying schemata.

Intentional Use of Ecological Invariants

According to Gibson (1979), the importance of the organism's perception of its environment is the affordance of an object or event. Affordances are defined by him as " invariant combinations of properties at the ecological level " (Gibson, 1979, pp 127-140). The basic postulate related to ecological processing of information is that there exists a continuous flow of information, that is information is everywhere. The consequences of this are, firstly, that the medium has to contain species-specific carriers of information, and, secondly, that the organism has to have a device for picking up the information from those carriers. For example, in vision, the flow of light must be interrupted, which means that perception requires discontinuity.

James J. Gibson's studies of visual awareness and his ecological approach to visual perception made it interesting to build up an experimental setting, in which the perception of discontinuity by young infants could be tested directly. The crucial problem of how to measure the result of this optical information processing, shown through behaviour in the infant proving the meaning of depth, was solved in such a way that Eleanor Gib-

son's interest in fear and avoidance was built in, connecting the two research goals. Thus from a meaningful behaviour that showed fear of hight the perception of depth could be inferred. Apart from this twofold experimental orientation, the findings on the visual cliff (Gibson & Walk, 1960) have had great implications for the knowledge of cognitive development. This well-known experimental approach will now be put into the formalism (1) in order to describe the organism-environment interaction process.

The structure embedded in formula (1) may be visualized as a complementary arrangement of its components in a three-dimensional space. The process anticipated to operate in this structure has been described in Bierschenk (1984 a; 1984 b; 1986). The manipulation of the action component (4) manifests itself through a binding of the values (-,+) to the A and O components respectively. Binding these values with respect to the complementary roles of A and O gives the events described by the picture series of Gibson & Walk (1960, p 65). All pairings possible in the described event space are (--, -+, +-, ++) and the change of information in the picture series can be studied except for the first combination of symbols. A fixation of both organism and environment means zero processing. The first measure carried out is a fixation of the A component representing the organism to which the value (-) is bound. The second measure implies a binding of the value (-) right adjusted. The result (--) is depicted by the top left picture of the visual cliff series: A child placed on the center board.

Gibson's ecological theory of perception presumes that the development of meaning be dependent on the viewpoints being changed. The third measure then implies mobilizing the O component to which the value (+) is bound. More than one viewpoint of the same kind are observed. No change of perspective is implied. The result (-+) is made visible by the top right picture: The child crawls to its mother across the " shallow " side.

Moreover, it is presumed that the observer's perspective can be viewed from various angles. By mobilizing the A component and

fixating the O component (+-) a change in perspective is observed. The result is documented by the bottom left picture: Called from the " deep " side, the child pats the glass.

It is further assumed that egomotion is encompassed in perception. The perception of the environment is an activity that twines together the perceiver and the perceived in an interactive relation, without which the meaning of the perceived cannot be established. The relationship thus described can be observed by mobilizing both the A and O components (++). The result implies maximal information synthesis, which is pictured bottom right: The inferred behaviour is that the child refuses to cross over to the mother.

The relations (--, ++) and (-+, +-) are complementary to each other. This double asymmetry gives every pair a certain control over the development of every other. The asymmetrical pairs constitute the mechanism for the developmental control over observational differentiation and integration. The significance of this double mechanism of change lies partly in a variation of object orientation, which makes available exterospecific information, partly in a variation of perspective, which allows the extraction of propriospecific information. Since, according to Gibson, a pictorial or symbolic expression incorporates both types, a matter of great concern will be the testing of the ability of language to mediate differentiation of ecological kind and to give expression to integration of experience into invariant structures.

The Observer-Event Involvement

Events are nested within events, they begin and end abruptly. Events are, basically, the discontinuities in the information flow. Labels such as information flow and motion are used to indicate the study of abstract change. But movement detection is not very useful by itself. The individual needs to know what has moved or changed. Thus in contradistinction to motion perception (Warren, 1978), the perception of information flow is based on the

following two dimensions:

1. detection of transformational invariants, which specify the nature of change, and
2. detection of structural invariants, which specify the identity of the structure that undergoes the change.

With this orientation in ecological information processing, we would like to stress the distinct fact that the Gibsonian approach to the study of perception has overcome the thing perspective, the all too concrete way of viewing stimuli. Whenever observational events structure the language of an observer, this language contains information belonging to these events.

Of particular significance for a cognitive approach is the question whether the AaO paradigm has the capacity of reflecting direct perception as it has been presented by Gibson. For a specification of structural information, an experiment was carried out, in which mothers of infants of crawling age have described the pictures from the visual cliff experiment (Bierschenk & Bierschenk, 1987). It was assumed that their empirical observations are packed in their language in such a way that information, i.e. the special value that the object-event relations mediate at the moment of perception, can be detected. By making explicit reference to the process of perceiving structure we refer neither to pictorial or image-like thought nor to thought that is verbal or symbolic. The invariants are assumed to reflect ecologically significant aspects. Thus the components of the model (5) are founded on an interest to present the interaction between individual and context. The question posed and investigated is the following:

> To what extent does language, describing direct observations with the point of departure in the ecological theory of perception, reflect invariances in such a way that these can be directly picked up by the components of the model?

It is commonly agreed upon that language is a more abstract level of processing than is vision. Nevertheless, a linguistic analysis has been capable of picking up the ecological invariants, although using language specific instead of vision specific cues.

What should be payed special attention to is that the higher order relations abstracted have been structurally represented by means of topologically described dimensions (Bierschenk & Bierschenk, 1987). The perspective invariants lying in the textual flow have been made visible by the transformations depicted in the form of a cubic space. Within that space, developing cognitive processes have not only been discerned but also been differentiated according to specific interests of the experimental subjects.

Five conceptually different profiles have been discerned. The main concern of the first profile relates to the attraction that the mother exerts over the child, compared to the experimental task. An instrumental conduct defines the second profile, while the third addresses a fear, elicited through the perceived curiosity in the child. The tenet of the fourth profile is a perceived separation anxiety. The fifth and final profile is closest to the experimental task and thus to the intention of the picture producers. Expression is given to two different kinds of affordances. The cognitive process signifies also the responsiveness to the appearance of the event. It is amplified that the picture series is incomplete, because the picture producers seem to have inferred the behaviour of the child on the deep side. Presumably a fifth picture would have been needed, because, as one parent words it, " what the outcome of this was, the pictures give no answer to ".

Discussion

The foundation of knowledge has been the central subject in philosophy and epistemological study during centuries. Despite the fact that many books and journals have been published on the matter, it is difficult to discern a generally accepted definition. The problem of knowledge has primarily been characterized as theoretical (Bunge, 1967) and therefore inappropriate for a scientific approach on empirical grounds. Epistemologists seem to maintain the position that experimentally working scientists

certainly are able to pile up lots of quantitative data and are able to apply statistical analysis on them. But they take for granted that this activity will not lead to an understanding of the phenomenon of knowing. To epistemologists it is evident that an understanding of the human mind requires a study of how human beings should think, which is intimately related to the study of the universals of logic, language, and symbolism in general.

Due to the fact that there is no way of proposing an unambiguous definition of the concept of knowledge, and due to the circumstance that knowledge to an ever increasing extent is used as a synonym to information, the approach chosen here to study the phenomenon of knowing has been process-oriented. This implies that we have given a demonstrative definition, in Sommerhoff's (1950, p 31) sense. Hopefully our approach could make clear that knowledge should not be looked upon as something objective that can be confirmed by means of principles of verifyability. Nor should it be conceived as something hopelessly subjective, which is unattainable for scientific analysis. Instead, knowledge has to be treated as something that exists only through a cooperative interaction between individual and environment.

The paper gives a short background to the concept of schema, which is the fundamental concept for self-referential systems. On the basis of the schematism of language, the agent (knower) has been identified as the integrative component, which gives it a steering function in the schematizing process when expressed in verbal behaviour. By founding a symbolic expression on a schema model, we have been able to demonstrate that the general cooperation of the organism with its environment requires the teleonomic concept (Monod, 1971) in order for the knower to express an intended and oriented schematization.

As exemplified by the picture series from the visual cliff experiments, the formalism proposed transforms the organism and environment through a twist into cognition. The twisting process has been discussed in Bierschenk (1986). A consequence of this transformation is that the perspective and viewpoints, which were dependent variables at the organism-environment level, become

independent variables and thus available for experimental manipulation at the next higher level. This further implies that the mechanism proposed ties the perspective to the A-component and the viewpoints to the O-component of the AaO paradigm. The manipulation of both components gets its expression through the fixation or activation of the a-component. The complementary role of the A-and O-components produces a communication process.

Inherent in the process of communication is the process of transforming meaningful behaviour into symbolic expressions. At this level, the transformation entwines the perspective and viewpoints in the same way as organism and environment are entwined. Therefore, the analysis of symbolic expressions could not be carried out before we were able to experimentally detach the textual perspective from its viewpoints. Of particular importance for the process of detaching perspective from viewpoints is the assumption that the empirical observations are linguistically packed in such a way that ecologically valid information can be discovered. By this is meant the particular affordance that objects and events have for the knower at the moment of perception. Because it is assumed that a picture can function as a link between awareness and cognition, the picture series from the visual cliff experiments has been described verbally by parents of infants of crawling age. Their free and unrestricted verbal descriptions have been made the basis for our analysis. We were able to use the extracted relations for a topographical description of perceived dimensions (Bierschenk & Bierschenk, 1987). On the basis of the textual transformations made visible in the form of a cubic space, it became obvious that the known conceptually divides into five different profiles. These give expression to different cognitive processes and are differently structured both in relation to each other and in relation to the source of observation (the knower).

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The researcher	A	the knower
observed	a	
A a [ø]	O	the known (integrated experience)
that		
the infants	A	the experiencer
crawled	a	
over the cliff	O	the environment

Comment:
The dummy [ø] symbolizes some environmental variable, which may be an object or an event. In this case it is an event, which incorporates an agent and an environment/object. The relation between the two agents is asymmetrical in the sense that A(2) is experiencing an unknown environment, while A(1) has already integrated this kind of environments. Thus the experiencer- environment event is known to him. Consequently, in his observations (e.g., as reported verbally) the knower is always present in the known.

Figure 1. The function of the schema in formalizing awareness.